

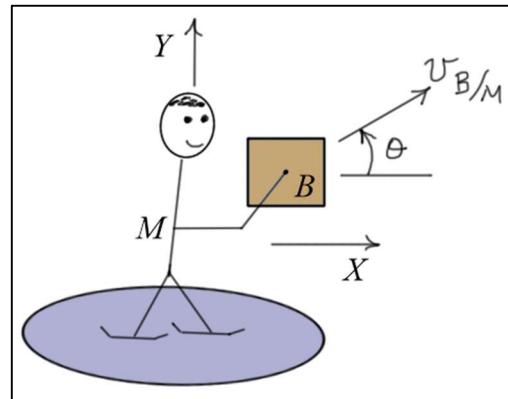
### Elementary Dynamics Example #25: (Conservation of Momentum)

Given:  $v_{B/M} = 2 \text{ (m/s)}$ ,  $m_B = 8 \text{ (kg)}$ ,  $m_M = 70 \text{ (kg)}$ ,  $\theta = 30 \text{ (deg)}$

system (block and man) is initially at rest  
man throws block in  $\Delta t = 1.5 \text{ (sec)}$

man is on **ice**, legs are **rigid**  
arm mass is **negligible**

Find: a) velocity of man just after releasing block  
b) average normal force the ice exerts on man



Solution: (using **conservation of momentum**)

a) Linear momentum is conserved for the system in the  $X$  direction, and the relative velocity can be used to relate the absolute velocities.

$$0 = m_M (v_M)_x + m_B (v_B)_x \quad \text{and} \quad (v_{B/M})_x = (v_B)_x - (v_M)_x = 2 \cos(30)$$

Simultaneous equations:

$$\begin{aligned} 70(v_M)_x + 8(v_B)_x &= 0 \\ -(v_M)_x + (v_B)_x &= 2 \cos(30) \end{aligned} \Rightarrow \begin{cases} (v_M)_x = -0.1776 \text{ (m/s)} \\ (v_B)_x = +1.5544 \text{ (m/s)} \end{cases}$$

b) Impulse and momentum in the  $Y$  direction

$$\underbrace{\sum (mv_y)_1}_{\text{zero}} + \sum I_{1 \rightarrow 2} = \sum (mv_y)_2 \quad (1 \text{ is before the throw and 2 is just after})$$

$$\sum I_{1 \rightarrow 2} = (N_{\text{avg}} - m_M g - m_B g) \Delta t = 1.5 (N_{\text{avg}} - 78g)$$

$$\sum (mv_y)_2 = \underbrace{0}_{\text{neglecting momentum of the arms}} + m_B (v_B)_y = 8(2 \sin(30)) = 8$$

Solving,

$$N_{\text{avg}} = 771 \text{ (N)} = 78.6 \text{ (kg)} \quad (\text{just slightly larger than the combined weights of the man and block})$$